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Large aperture kinoform phase plates in fused silica for spatial beam smoothing on Nova and the Beamlet lasers

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It is now widely recognized that spatial beam smoothing (homogenization) is essential in coupling the laser energy to the inertial confinement fusion (ICF) targets [1]. For the indirect drive approach to ICF [1], it is desirable to distribute the laser energy into a uniformly speckled profile that has a flat-top super-Gaussian envelope (8th power or higher) and contains greater than 95% of the energy inside the super-Gaussian profile. Binary random phase plates (RPPs) currently in use [2] do not meet these requirements since the far-field intensity profile is restricted to essentially an Airy function containing only 84% (an upper limit) of the energy inside the central spot. Approaches using lenslet arrays (refractive or diffractive) [3,4] have limited use since they operate in the quasi-far-field and have a short depth of focus.

The limitations of the RPPs can be overcome by relaxing the binary phase constraint. We have recently presented [5] continuously varying phase screens for tailoring the focal plane irradiance profiles. Called kinoform phase plates (KPPs), these phase screens offer complete flexibility in tailoring the focal plane envelope and, at the same time, increasing the energy efficiency inside the focal spot. We have designed fully continuous phase screens [6] for producing superGaussian focal plane envelope profiles that contain greater than 98% of the incident energy inside the central superGaussian spot.

These phase plate designs are fabricated in fused silica substrates by the lithographic approach using multiple binary masks and wet etching in a buffered hydrofluoric acid solution. Here the fully continuous phase screen (several waves deep) is first re-wrapped into a one-wave deep, mod 2π phase profile and this wrapped kinoform phase profile is quantized into sixteen discrete levels. This discretized structure is fabricated by successive superposition of four binary masks and a differential etching of the KPP substrate at each step. Production of precise masks and an accurate overlay of these masks on the KPP substrate is critical to maintaining a high diffraction efficiency in the focal spot. We have developed facilities for generating precise masks and for their alignment on the KPP substrate. Using these facilities, we have fabricated large aperture KPPs for use on the Beamlet laser (~40 cm square aperture) and on Nova (65-cm diameter aperture). The details of the KPP design, their fabrication and performance on Beamlet and Nova lasers will be discussed during this presentation.

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References

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